ACCESSION #: 9801160136

NON-PUBLIC?: N

LICENSEE EVENT REPORT (LER)

FACILITY NAME: WATERFORD STEAM ELECTRIC STATION UNIT 3 PAGE: 1 OF 16

DOCKET NUMBER: 05000382

TITLE: REACTOR TRIP AND NON-SAFETY RELATED SWITCHGEAR FIRE

EVENT DATE: 06/10/95 LER #: 95-002-01 REPORT DATE: 01/13/98

OTHER FACILITIES INVOLVED: N/A DOCKET NO: 05000

OPERATING MODE: 1 POWER LEVEL: 100

THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR SECTION:

50.73(a)(2)(iv) & 50.73(a)(2)(x)

LICENSEE CONTACT FOR THIS LER:

NAME: T.J. GAUDET, LICENSING MANAGER TELEPHONE: (504) 739-6666

COMPONENT FAILURE DESCRIPTION:

CAUSE: X SYSTEM: EA COMPONENT: BKR MANUFACTURER: G080

REPORTABLE NPRDS: Y

SUPPLEMENTAL REPORT EXPECTED: NO

ABSTRACT:

On June 10, 1995, a fault recorder at the Waterford Switchyard recorded a single phase fault. Subsequent inspection identified a failed C phase lightning arrestor on a Substation Transformer. At approximately the same time, with the plant in mode 1 at 100% power, a reactor trip occurred, and one of the two independent offsite power sources was lost. Shortly thereafter, a report was received from the Turbine Generator Building (TGB) operator of smoke in the TGB switchgear. The 4.16 KV non-safety related A2 bus in the TGB switchgear caught fire causing damage to the bus and surrounding cables and components. The fire damage was limited mainly to the Unit Auxiliary Transformer

Feeder Breaker supplying the A2 bus and the adjoining meter cabinet. The root cause of the fire in the A2 switchgear was the improper automatic bus transfer from the Unit Auxiliary Transformer to the Startup Transformer and the root cause of the reactor trip was low Departure from Nucleate Boiling Ratio. During the recently completed Refueling Outage, a new automatic bus transfer scheme was installed at Waterford 3. This event did not compromise the health and safety of the public.

REPORTABLE OCCURRENCE

This event resulted in an automatic reactor shutdown and involved a fire which required the declaration of an Unusual Event. Therefore, this event is reportable pursuant to 10CFR50.73(a)(2)(iv) and 10CFR50.73(a)(2)(x).

INITIAL CONDITIONS

At the start of this event on June 10, 1995, Waterford 3 was in mode 1 (Power Operation) at 100 percent power. No procedures specific to this event were being performed. There were no Technical Specification (TS) Limiting Conditions for Operation (LCOs) in effect specific to this event. Also, there was no major equipment out of service associated with this event.

EVENT DESCRIPTION

On June 10, 1995, at 0858 hours, Waterford 3 was operating at approximately 100% power in mode 1 (Power Operation). The following sequence of events describe the major occurrences associated with this event.

08:58 The event was initiated by a failed phase C lightning arrestor [LAR] on the Waterford Substation #2 Transformer (230 KV/34.5

KV) [FK-XFMR]. The resulting grid disturbance caused the Sudden Pressure Relay [EA-RLY] on the Main Transformer A [EA-XFMR] to actuate the Main Generator lockout relays [TB-RLY]. These relays perform the major protective functions of tripping the generator output breakers [EL-BKR], tripping the generator exciter field breaker [TL-BKR], tripping the main turbine [TA], tripping the Unit Auxiliary Transformer (UAT) secondary breakers [EA-BKR], closing

the Startup Transformer (SUT) secondary breakers [EA-BKR], and tripping the heater drain pumps [SJ-P].

The B1 7KV bus [EA-BU] successfully transfers to the SUT. The A1 7KV bus [EA-BU] appeared to successfully transfer to the SUT. The A2 and B2 4.16 KV buses [EA-BU] attempt to transfer to the SUTs. The B2 bus successfully transfers.

The reactor trips on low Departure from Nucleate Boiling Ratio (DNBR) when Reactor Coolant Pump (RCP) [AB-P] speed of less than 96.5% of rated RCP speed is detected. All Control Element Assemblies (CEAs) [AA] insert into the core.

The A2 SUT feeder breaker [EA-BKR] tripped on overcurrent. An undervoltage lockout relay [EA-27] tripped. The A3 4.16 KV safety bus is deenergized. Emergency Diesel Generator (EDG) A [EK-DG] starts and picks up the loads on the safety related

bus.

Operators enter OP-902-000 Emergency Entry Procedure.

Feed Water Pump Turbine (FWPT) A [SJ-P] overspeed trip is indicated on the sequence of events (SOE) log. The FWPT is believed to have actually tripped when the feedwater pump speed pickups lost power and sent a signal to close the feed water pump governor valve.

08:58 Emergency Feedwater Actuation Signal-1 (EFAS-1) Actuated.

08:58 EFAS-2 Actuated.

09:05 Main Feedwater Isolation Valve (MFIV) #2 [SJ-V] closes on high Steam Generator level (96% Wide Range with 800 psia).

09:06 TGB Operator reports smoke coming from the TGB switchgear [EA-SWGR] room. Simultaneously, a report is received by telephone in the control room of smoke coming from the east side of the TGB. This report was initiated by employees working in the Generation Support Building (GSB). The Shift Supervisor (SS) orders two Nuclear Auxiliary Operators (NAOs) to don bunker gear to enter the room and investigate. The Operations Superintendent noticed light white smoke exiting the TGB while reporting to the control room.

09:11 MFIV #1 closes on high Steam Generator level.

09:21 Operations enters OP-902-005 "Loss of Off-Site Power/Station

Blackout Recovery Procedure".

09:35 Fire is reported above the A2 switchgear. The SUT A motor operated disconnect [EA-MOD] is manually opened by the control room to aid in extinguishing the fire. An NAO and additional fire brigade members attempted to extinguish the fire using Halon, CO2, and dry chemical extinguishers.

09:41 The Hahnville Fire Department is contacted via 911 for support.

09:45 An Unusual Event is declared due to the fire in the protected area lasting longer than 10 minutes.

09:58 Hahnville Fire Department arrives on site.

10:18 Hahnville Fire Department applies water to the insulation above the A2 bus.

10:22 Fire Team Leader reports the fire appears to be extinguished.

11:13 The fire is declared out and reflash watch is set.

11:59 Atmospheric Dump Valves [SB-V]) are automatically cycling to control Reactor Coolant System (RCS) [AB] temperature.

13:52 Waterford 3 exited from the Unusual Event.

14:15 Commenced plant cooldown.

CAUSAL FACTORS

The failed phase 'C' lightning arrestor on the Waterford Substation #2 Transformer (230 KV/34.5 KV) led to three major events: (1) inadvertent Main Transformer sudden pressure relay 'A' trip, (2) fire in the A2

switchgear, and (3) reactor trip.

LP&L Southern Region Report SY-95-14, which documents the special diagnostic test results on the sudden pressure relays for both 'A' and 'B' main transformers, indicates the root cause of the inadvertent main transformer sudden pressure relay 'A' trip is that the 'A' main transformer sudden pressure relay time limits were slightly below band. The root cause of the fire in the A2 switchgear was the improper automatic bus transfer from the UAT to the SUT. The "fast dead bus transfer" allowed the SUT breaker to close although the UAT breaker failed to trip. This condition caused the A2 bus to temporarily connect SUT 'A' to the main generator [TB-GEN] which then provided power to the grid via the UAT and A2 bus at that time. This is confirmed by the fault tracing from the Waterford switchyard fault recorder. When the UAT breaker attempted to open, it tried unsuccessfully to interrupt the current. During this time, the main generator was rotating faster than the system frequency. Just prior to the time the breaker attempted to open, the Waterford switchyard fault recorder indicated the current flow on the 4 KV bus to be excessive and approaching 180 degrees out of phase. This condition apparently caused the breaker's interruptable rating to be exceeded. When the UAT breaker tried to open, it failed internally creating ionizing gases. The ionizing gases were the most likely cause of the fire in the A2 switchgear. A preliminary internal investigation,

with assistance from General Electric (GE) Engineers, concluded that the most probable cause for the slow opening time of the UAT breaker was restricted movement of the trip latch roller bearing. The purpose of the trip latch roller bearing is to provide a low friction rolling surface for free movement of the trip latch, which collapses the four bar linkage, thereby opening the main contacts. The bearing appeared to be sluggish in movement between the inner and outer bearing races and the bearing surface was found to be covered with hardened grease. This could be attributed to the heat of the fire which burned the grease on the bearing surface. Inspection of similar breakers in the plant determined they are not

covered with the hardened grease. Additionally, the inspection identified that the trip latch roller bearing on the feeder breaker to the 221A bus was difficult to operate. The trip latch roller bearing was subsequently replaced.

The degree of damage to the breaker and surrounding equipment indicates that the fault energy of the breaker was extremely high. Due to the extent of the damage during this failure, evidence normally utilized to evaluate the conditions of the circuit breaker was not available. The arc chutes were destroyed, the contact structures were damaged extensively, and the breaker frame and cubicle were also damaged. The main bus and bus compartment experienced severe arcing damage. The

center phase (A phase) of the breaker sustained the worst damage. The right phase (B phase, looking at the front of the breaker) arcing contact was hardly damaged, the middle phase arcing contact was totally destroyed, and the left one (C phase) was partially destroyed. The main contacts on all the phases were destroyed.

The root cause of the reactor trip was low Departure from Nucleate Boiling Ratio (DNBR) as a result of low Reactor Coolant Pump (RCP) speed. RCPs 1A and 2A, powered from the A1 bus, were coasting down as a result of the loss of voltage to the bus. At 96.5% of rated speed, the Core Protection Calculators (CPCs) [JC] inserted a 0.1 multiplier to the DNBR calculation. This caused the reactor to trip on low DNBR.

CORRECTIVE MEASURES

Immediate corrective measures consisted of extinguishing the fire and placing the plant in a safe condition. The following actions were also taken:

1.) Damage Assessment

On June 10, 1995, the A2 bus in the Turbine Generator Building Switchgear caught fire causing damage to the bus and surrounding cables and components. The initial assessment of the fire determined that it originated in the A2 bus #1 cubicle. The fire caused major damage to the #1 & #2 cubicles and destroyed approximately 10 feet of the feeder cables. Cubicle #1 contained the 4160 volt feeder from the Unit

Auxiliary Transformer (UAT) and Cubicle #2 contained the Potential Transformer and associated relays and components. There was general smoke and slight heat damage to the exterior of the remaining cubicles in the A2 bus. In addition, there was external heat damage to the jackets of four (4) of the fifteen (15) feeder cables from the Start Up Transformer (SUT) to the A2 bus. There were also burn marks on the conduit of the cables which supply 6.9 KV to RCP 1A and 2A motors.

2.) Bus Repairs and Testing

The cables from UAT A were damaged to such an extent that they could not be repaired in a short period of time. Efforts were thus concentrated on restoring the SUT A feeder to the A2 bus. Cleanup started immediately after electrical power to the A2 bus was removed and danger tagged by Operations. Breakers and relays were removed from the A1 and A2 bus cubicles to clean and calibrate the components and perform Preventive Maintenance (PM) tasks. Also, because of extensive cable damage, the copper buses in cubicles #1 & #2 were removed from the A2 bus and a Temporary Alteration Request (TAR) was initiated to isolate the cubicles. The A1 and A2 buses were then ready for reenergization.

3.) Cable Repairs and Testing

The cables from SUT A to the A2 bus were meggered, power factor tested and vendor (CM Technologies Corporation) Electronic Characterization and Diagnostics (ECAD) tested with acceptable results. The ECAD testing

consisted of a series of tests to verify continuity, insulation integrity and identify any fault locations in the cables. The damaged sections of the outer jackets were removed and after discussions with the cable vendor (Okonite), a Raychem kit (heat shrink) was recommended and installed to wrap the cables. The same series of tests were once again performed on the cables to verify acceptable results. The cables from the A1 bus to the RCP 1A & 2A and Condensate Pump A & C motors [SD-P-MO] were meggered and ECAD tested with acceptable results. These cables were tested because they either had fire damage or were suspected of having fire damage due to their close proximity to the fire. The test results for these cables were evaluated by Waterford Engineering, ECAD Field Engineers, and Okonite Service Representatives and determined to be acceptable.

4.) Transformer Repairs and Testing

Main Transformer (MT) A, UAT A, and SUT A were power factor and megger tested with acceptable results. The Sudden Pressure (SP) relays for MT A & B were also tested with acceptable results. However, the SP relay for MT A, which caused the Main Turbine Trip, was found to be slightly more sensitive. The SP relays on the Main Transformers now provide an alarm function only. These transformers are still protected by two differential relaying schemes. In addition, oil samples were analyzed for the six (6) transformers (2 MTs, 2 UATs, and 2 SUTs) with acceptable results.

5.) Main Generator Testing

Potential damage to the Main Generator due to this event was discussed with Westinghouse to determine what testing, if any, would be required. Based on these discussions, Waterford Engineering determined that Main Generator testing was not required. However, the Main Generator Exciter was tested by Westinghouse to ensure proper operation. At the conclusion of the testing it was determined that the parameters were within limits.

Five fuses were found blown on the exciter wheel. However, the diodes associated with the blown fuses were found to be functional.

6.) Review of Maintenance Practices

An initial review by General Electric of Maintenance Procedure ME-04-131, "4.16 KV GE Magna-Blast Breaker," used for the UAT-A2 feeder breaker concluded Waterford 3 maintenance practices were adequate. Preventive Maintenance (PM) is performed on a three year interval and was performed on the following dates: March 26, 1984, April 27, 1984, February 8, 1987, and October 26, 1992.

A PM task was scheduled for November 6, 1989. However, since the PM could not be performed at that time, the PM was postponed until the 1992 refueling outage. In addition, the only Corrective Maintenance that was performed on the breaker dealt with the replacement of a light socket.

7.) Event Review Team

On June 11, 1995, an Event Review Team was assembled to investigate the events surrounding the reactor trip, fire, and partial loss of offsite power. As a result of this team's efforts, an Event Review Team Root Cause Analysis Report was prepared.

Four corrective actions to prevent recurrence were identified.

1. Additional evaluations on the design of the Electrical Distribution System were performed to determine the adequacy of the design. As a result of these evaluations, Plant Change (PC) 3448 was installed during Refueling Outage 8 (RFO8) which was completed on August 2, 1997. The three basic functions of PC 3448 are:

o To prevent the SUT supply breaker from closing while there is still a close signal to the UAT supply breaker (i.e., preclude parallel closure of the UAT and SUT supply breakers on the same bus). This is accomplished by adding an interlock between the UAT and SUT supply breakers

o Prevent an unacceptably slow closing SUT supply breaker (or failure of the breaker to close) from closing on the bus beyond a predetermined time, or exceeding the acceptable phase angle difference between the SUT feeder and the bus being transferred. Transfer limits are established by replacing existing timers with high accuracy timers and adding high speed synchronism check relays. The contacts from these devices are used as permissives in the SUT breaker closing circuit.

o Monitor the automatic bus transfer control circuit for electrical component failures. In the past, component failures have gone undetected and may have contributed to unsuccessful automatic bus transfers. Component failures in the transfer scheme can be detected and repaired prior to automatic bus transfer demands, resulting in successful transfers. Monitoring is accomplished by adding a dedicated annunciator which will monitor all active devices in the automatic bus transfer control circuits.

2. An in-depth review by GE and Waterford 3 System Engineering was conducted on the current maintenance practices associated with ME-04-131, "4.16 KV GE Magna-Blast Breaker." The review stated the procedure contained sufficient content and direction to guide a knowledgeable technician through the maintenance process and achieve the intended results. Although there were minor opportunities for improvements, the procedure was deemed adequate and acceptable.

3. Guidance was provided to the Fire Brigade on the identification of a fire in the absence of a visible flame. Waterford 3 placed a Standing Instruction in the control room subsequent to the June 10, 1995, fire in the protected area. The Standing Instruction states that a fire should be declared even without the actual observance of flames should the smoke and/or heat be of such degree that the use

of protective gear and/or Self Contained Breathing Apparatus (SCBA) equipment is considered.

4. Extensive testing was performed in an attempt to determine why the SUT feeder breaker to the A1 bus did not close. All circuitry was examined and tested with no conclusive results.

Waterford 3 operated on both SUTs until Refueling Outage 8 which began on April 11, 1997. Design Engineering-Electrical/I&C determined that operating from the SUTs would have no adverse impact on normal plant operations. This determination was based on calculation EC-E91-050 "Degraded Voltage Relay Setpoint & Plant Load Study". In addition, several Condition Reports were initiated to implement the Waterford 3 Corrective Action Program for minor problems associated with this event that were identified by the Event Review Team.

SAFETY SIGNIFICANCE

Loss of offsite power (LOOP) is assumed in the limiting safety analysis (FSAR Chapter 15 transients and accidents), if the LOOP makes the consequences of the event worse. The Loss of Normal AC Power analysis (FSAR Sub-section 15.2.1.4), which assumes loss of all offsite power (and thus simultaneous losses of load, feedwater, reactor coolant pumps, circulating water pumps [NN-P], and condensate pumps) bounds the loss of the A2 bus. This is, therefore, an analyzed event. All safety systems operated as designed throughout this event. The consequences of this

event are less severe than the previously analyzed Loss of Normal AC Power event.

The impact of this event is on the probability of core damage, an area addressed by the Probabilistic Safety Assessment (PSA). In Supplement 4 to Generic Letter 88-20, the NRC requested each licensee to perform an Individual Plant Examination of External Events (IPEEE) to address the severe accident (core damage) risk posed by external

events (which include fires). The risk posed by a fire in the TGB switchgear room was identified and addressed in the Waterford 3 Fire IPEEE which was submitted in July of 1995. The fire that occurred in the UAT to A2 bus breaker is one of the most severe TGB switchgear fires that can reasonably be expected, since it involved a very high fault current in a large breaker, producing a fully-involved switchgear fire with major insulation combustion.

Although the heat release rate was undoubtedly large (estimated to be much larger than in most switchgear fires), severe damage was limited to two cubicles on the A2 bus and the cables in the UAT A to A2 bus duct. Minor damage occurred to the SUT A to A2 bus duct and adjacent A2 and A1 switchgear cubicles. The B train of offsite power (SUT B to B2 and its bus duct tie to B3) was not affected. The two trains of offsite power are well separated; the bus ducts are physically separated by about 20 feet and the switchgear cubicles themselves are separated by a concrete

block radiant shield. The degree of separation and the fact this fire had no effect on the B train of offsite power make the possibility of a TGB switchgear fire that could fail both trains of offsite power remote. The risk of core damage immediately after the fire or during the time when the plant is in a degraded condition (loss of the A train of offsite power, with the A3 bus powered by EDG A) was on the order of the average yearly core damage risk for all causes. When the plant tripped, continued feedwater flow was necessary for decay heat removal. The trip put a demand on the plant to respond to the ensuing transient. If the main feedwater pumps were lost (as eventually occurred), Emergency Feedwater (EFW) [BA] would be needed to maintain decay heat removal. There was a small probability that EFW would have failed to start, and that the Startup Feedwater [SJ] pump would

also have failed. Once EFW started, it was unlikely that all three pumps would fail to run (including pump A failure as a result of EDG A failure).

The average annual frequency of a severe fire in the TGB switchgear room can be estimated as 0.125 per year (1 event in about 8 years on-line). This conservatively assumes that a fire such as the June 10, 1995, event will happen on average every 8 years, which is about an order of magnitude higher than the frequency expected from generic data. If this conservatively high fire frequency is used in the Fire IPEEE analysis,

with the realistic assumption (based on the damage observed in this event) that a TGB switchgear fire cannot fail both offsite power trains, the TGB switchgear fire scenario is of relatively low average risk (the average probability of core damage is estimated to be about 2E-6 per year, or about 10 times lower than the overall average yearly core damage probability). The primary reason for the low risk is the availability of multiple, diverse feedwater sources and the availability of offsite power B and both EDGs. This low core damage risk indicates that the plant is not vulnerable to core damage as a result of an event such as this.

This core damage probability estimate used a model applicable to post-trip, Mode 3 conditions, when feedwater to a steam generator is required for decay heat removal, Once the plant was on Shutdown Cooling [BP], the risk was lower than estimated because the lower decay heat level, pressure, and temperature would give operators much more time to respond to possible Shutdown Cooling failures before core damage would occur.

Since loss of offsite power is an analyzed event, the fire on the A2 bus does not affect the conclusions of the safety analysis. All safety systems operated as designed throughout this event. The average annual core damage risk for a TGB switchgear fire

(including this event) is very low, indicating that Waterford 3 is not vulnerable to core damage from an event such as this. Based on the

above, the health and safety of the public was not compromised.

SIMILAR EVENTS

Waterford 3 received an operating license authorizing full power operation in 1985. A review of Licensee Event Reports (LERs) dating back to that time revealed no pattern of similar recurring events. However, four LERs documenting grid disturbances that affected the operation of Waterford 3 were identified. These four LERs are LER-85-054-00, LER-90-003-01, LER-90-012-00, and LER-91-013-01.

ADDITIONAL INFORMATION

Energy Industry Identification System (EIIS) codes are identified in the text within brackets [ ].

*** END OF DOCUMENT *** ATTACHMENT 1 TO 9801160136 PAGE 1 OF 1

Table "REQUIRED NUMBER OF DIGITS/CHARACTERS FOR EACH BLOCK" omitted.